Gastropod Surveys of Three Creeks May - October 2021

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Introduction

Species Information: Oregon Forestsnail

The Oregon forestsnail (*Allogona townsendiana*) is a large terrestrial snail endemic to western North America. The slightly flattened shell of this species varies in colour from light brown to straw yellow and has a diameter of 28-35 mm as an adult (Figure 1). The outer layer of the shell can become bleached and flake off with age. A thickened whitish apertural lip distinguishes this species from other large land snails such as the Pacific sideband snail (*Monadenia fidelis*) and grove snail (*Cepaea nemoralis*) (Oregon Forestsnail Recovery Team; OFRT 2012).

The Oregon forestsnail is found in the Coastal Douglas-fir (CDF) and Coastal Western Hemlock (CWH) biogeoclimatic zones, occupying mixed and deciduous forest habitat. In BC, the Oregon Forestsnail is restricted to the Fraser Valley Lowlands and southeast Vancouver Island. Canopy cover is typically composed of bigleaf maple (*Acer macrophyllum*), black cottonwood (*Populus trichocarpa*) and scattered western red cedar (*Thuja plicata*) (BC Conservation Data Centre 2017). Occasionally, the Oregon forestsnail is found using a combination of meadow and forest habitat (Edworthy et al. 2012). Soft and insulating soil is required for nesting and cover habitat (Steensma et al. 2009). There is also a strong association with stinging nettle, as it provides an important source of calcium and other minerals necessary for shell growth, and its presence is also an indicator of the moist environment preferred by the Oregon forestsnail (OFRT 2012). In addition, coarse woody debris is often associated with occurrences of the species (Steensma et al., 2009; Edworthy et al. 2012).

The Oregon forestsnail is hermaphroditic but is unlikely to self-fertilize (OFRT 2012). Mating season ranges from February to June peaking in March and April. Eggs are laid in small depressions dug into the substrate and one study calculated an average clutch size of 34 eggs. Juveniles hatch 8-9 weeks after oviposition and begin dispersing immediately. In dry conditions this species goes into aestivation to conserve moisture. During the cold winter months, the Oregon forestsnail burrows into leaf litter or retreats under coarse woody debris and hibernates (Steensma et al. 2009). A study completed on a population in Langley, British Columbia, shows that they have low dispersal ability. The maximum distance moved by a snail in one day was 4.5 m and home ranges ranged from 18 to 404 m^2 (Edworthy et al. 2012).

The Oregon forestsnail is assessed as endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and is listed under Schedule 1 as endangered by the *Species at Risk Act* (SARA). The BC conservation data center identifies this species as red-listed (BC Conservation Data Centre 2017). The habitat requirements of the Oregon forestsnail overlaps with the most densely populated and developed areas of British Columbia. Habitat

loss and degradation due to commercial and residential development poses the most serious threat to this species. Remaining suitable habitat occurs in small, isolated patches. The effects of genetically isolating populations are currently unknown (OFRT 2012).

Recreational activities such as mountain biking and hiking also threaten the Oregon forestsnail habitat through soil compaction and trampling. Introduced invertebrates may threaten this species by competing for resources, such as food and shelter, and predation. Invasive plants can also be deleterious to Oregon forestsnail habitat by changing vegetation structure in ways that may reduce moisture retention in the forest. These invasive plants may also outcompete native vegetation important to the life cycle of this species, including stinging nettle (OFRT 2012).

Land snails such as the Oregon forestsnail provide important ecological functions as decomposers of live and decaying plant matter (OFRT 2012) and dispersal of seeds and fungal spores (Edworthy et al. 2012). A better understanding of this unique species will allow for more informed and effective conservation efforts.

Figure 1: Adult Oregon forestsnail. Note the shell has become bleached and flaky with time and the thickened whitish apertural lip.

Species Information: Pacific Sideband

The Pacific sideband (*Monadenia fidelis*) is a large land snail that occurs along the west coast of North America. The slightly flattened shell of this species has a diameter of 22-36 mm and is brown with a yellow band around the outer whorl (Figure 2). In some cases, this species can

also be blond in colour with faint banding. The apertural lip of this species is slightly thickened and is dark brown in colour, unlike the white apertural lip of the Oregon forestsnail. A distinguishing feature of this species is the rosy brown colour and rough texture of the animal's body (Forsyth 2004). The Pacific sideband snail is hermaphroditic and inserts tiny projectiles covered in hormonal mucus prior to mating to improve sperm survival (Zevit et al. 2012).

The Pacific sideband occurs from northwestern California to British Columbia with an unverified detection in Sitka, Alaska (Forsyth, n.d.). In British Columbia, the Pacific sideband occurs in the Coastal Douglas-fir (CDF) and Coastal Western Hemlock (CWH) biogeoclimatic zones extending as far north as the Central Coast Regional District. The species occurs in deciduous, coniferous or mixed forests as well as open woods and grassy areas. This snail is often found climbing trees and has been found as high as 6.7 m above ground (BCCDC 2014; Forsyth 2014).

In 2016, the Pacific sideband was down-listed from special concern (blue-listed) to apparently secure (yellow listed) by the BC Conservation Data Center. This species is not ranked by COSEWIC or SARA. However, the species is negatively affected by habitat loss and degradation caused by residential and commercial development, agriculture, and forestry (BC Conservation Data Centre, 2016). There are several significant gaps in our knowledge of this species. A better understanding of the habitat requirements of the Pacific sideband will help with its conservation efforts and ensure its distribution and abundance remain stable. Hence, irrespective of the down listing we continued to include Pacific sidebands in our mark-recapture study, our goal is to generate valuable long-term data that will help us understands the longevity and habitat requirements for this species.

Figure 2: Adult Pacific sideband. Note the yellow band around the outer swirl and the rosy brown colour and rough texture of the animal's body.

Goals and Objectives

In 2014, a mark-recapture study was implemented on the Three Creeks conservation property owned by the Fraser Valley Conservancy (FVC). This study is intended to increase our knowledge of the at-risk gastropod species occurring on this property and to monitor these snail populations. Surveys have been repeated annually, except for the spring of 2019.

The objectives of this project are:

- To provide baseline data on the populations of Oregon forestsnail and Pacific sideband occurring on the Three Creeks property;
- To determine where on the property the snail species occur, and which habitats are being utilized;
- To estimate the population size of the Oregon forestsnail and Pacific sideband as well as survival rate and longevity; and
- To identify optimal times of year for Oregon forestsnail surveys and detectability.

Study Area

The FVC's Three Creeks property is located on the south side of McKee Road, across the street from Ledgeview Golf Course, in Abbotsford, BC. Access to the property is through a gate located at the east end of Ledgeview Drive. This property was donated to the conservancy in in 2013, with 0.2-acre addition in 2017, the current size totals 8 acres.

The parcel consists primarily of mixed forest habitat on a north facing slope of McKee Peak (on Sumas Mountain). Three creeks flow through the site which is dominated by mature cedar, bigleaf maple, sword fern and stinging nettle vegetation. The property provides valuable habitat for many species, including amphibians, mammals, songbirds and raptors. It is also home to several species at risk including Oregon forestsnail, mountain beaver, Northern red-legged frog and possibly Pacific water shrew. The property is nestled between housing developments (existing and pending) but connects directly to natural habitat to the south providing an important corridor for wildlife. The FVC's long-term objective is to monitor and manage the property to ensure it remains a valuable ecological resource to the community in perpetuity.

The property is located in the Coastal Western Hemlock, Dry Maritime (CWHdm) biogeoclimatic subzone within the Georgia Depression Ecoprovince of the Lower Mainland Ecoregion and the Fraser Lowland Ecosection.

Methods

Surveys were conducted following draft Oregon forestsnail mark-recapture and monitoring study protocols (Heron 2018) and amended to suit the amount of time and funding allocated to this project (see Appendix A). Since 2018, due to low mark-recapture rates in previous years we decided, in consultation with Jennifer Heron, to do two spring surveys when the snails are most active and one fall survey.

In 2021, the surveys were conducted on May 7th and 26th and October 6th. A total of 19 permanent survey plots are located throughout the Three Creeks property. Plots are marked with 2' rebar and flagging tape. UTM coordinates were recorded for each plot as well as aspect, slope, overstory species, slope position, time, surveyor initials, and soil comments. A category was recorded for moss cover, amount of coarse woody debris, type of light at snail level, moisture level, and disturbance (Appendix A).

At each location a 5 m radius survey area was delineated using marking flags and/or flagging tape. During the second spring surveys, an abbreviated BEC vegetation survey was completed using the Ecosystem Field Form (BCMFR & BCMOE 2010). All vegetation located in the plots was identified and percent cover was recorded. Following the vegetation survey, a total of 20-person minutes (6 minutes and 20 seconds with three surveyors; 5 minutes with four surveyors) were spent searching the plot for all gastropod species. Surveyors sifted through leaf litter, searched under vegetation, and examined logs and tree trunks. All specimens were placed in a surveyor specific bowl for later identification to minimize interruption of search time.

Following the search, all gastropod species were identified and recorded. Live and dead specimens were distinguished. Oregon forestsnail and Pacific sideband were measured using digital calipers and given a unique number identifier. Marked snails were numbered consecutively by species using nail polish. Live snails were returned to where they were found. Empty shells were left at the center of the plot.

Transects were walked between survey plots and any incidental sightings of Oregon forestsnails and Pacific Sidebands were identified. Incidental snails and shells were marked and measured then left where found after the GPS position of the site was recorded.

Results

Surveys of the Three Creeks property covered 4.7% of the 8 acres. In total 380-person minutes were spent searching in each of the two spring and the one fall survey sessions (for a 2021 total of 1140 person minutes). Overall, 196 gastropods were identified in survey plots (122 live; 74 dead). In the plots we found 27 Oregon forestsnails and 20 Pacific sidebands and between plots as incidental sightings we documented 19 Oregon forestsnails and 9 Pacific sidebands. In 2021, 9 Oregon forestsnails and 1 Pacific sideband were recaptured, previously

marked individuals, of which 2 individuals were recaptured twice in 2021. However, 8 snails' numbers were illegible and were remarked with a new number.

Spring Surveys 2021

The spring surveys were conducted on May 7th and 25th, and a total of 121 gastropods were identified (91 live; 30 dead) within plots. See Table 1 for a list of species and numbers identified. The average number of gastropods per plot was 2.3 for the May 7th survey and 4.2 for May 27th (n=19). 13 live and 7 dead Oregon forestsnails and 13 live and 1 dead Pacific sidebands were detected within plots. 10 Oregon forestsnails and 2 Pacific sidebands were detected incidentally between plots (Figure 3). Out of the 30 Oregon forestsnails found 8 were previously marked individuals.

Table 1: Gastropod species identified, numbers found dead and live, and the number of plots containing each species for spring surveys in 2021.

Common Name	Scientific Name	# Live	# Dead	Total	% Plots	Avg/plot
Oregon forestsnail	*Allogona townsendiana*	13	7	20	32	1.1
Pacific sideband	*Monadenia fidelis*	13	1	14	42	0.7
Lancetooth	*Haplotrematidae family*	24	20	44	89	2.3
Chocolate arion	*Arion rufus*	0	0	0	0	0
Northwest hesperian	*Vespericola columbianus*	23	3	26	53	1.4
Grove snail	*Cepaea nemoralis*	0	1	1	5	0.1
Pacific banana slug	*Ariolimax columbianus*	19	0	19	53	1.0

The average size of alive Oregon forestsnails found, including incidental observations (n=20), was 28.6 mm while the average size for alive Pacific sidebands (n=14) was 32.6 mm. Table 2 details the minimum, maximum and average sizes of these species.

Table 2: Average measured size of Oregon forestsnail and Pacific sideband for alive and dead specimens found for spring surveys in 2021. Not all dead specimens were measured due to shell damage.

	Average Size (mm)	SD	Minimum (mm)	Maximum (mm)
Live Oregon forestsnail (n=20)	28.6	2.0	23.9	31.7
Dead Oregon forestsnail (n=5)	28.8	0.6	28.0	29.8
Live Pacific sideband (n=14)	32.6	1.9	27.8	35.3
Dead Pacific sideband (n=1)	33.3	NA	NA	NA

Live and dead Oregon forestsnails and Pacific sidebands have been found throughout the property. However, consistently since 2014, the majority of both live and dead detections have been on the southern half of the parcel, and this was also the case in the spring of 2021 (Figure 3).

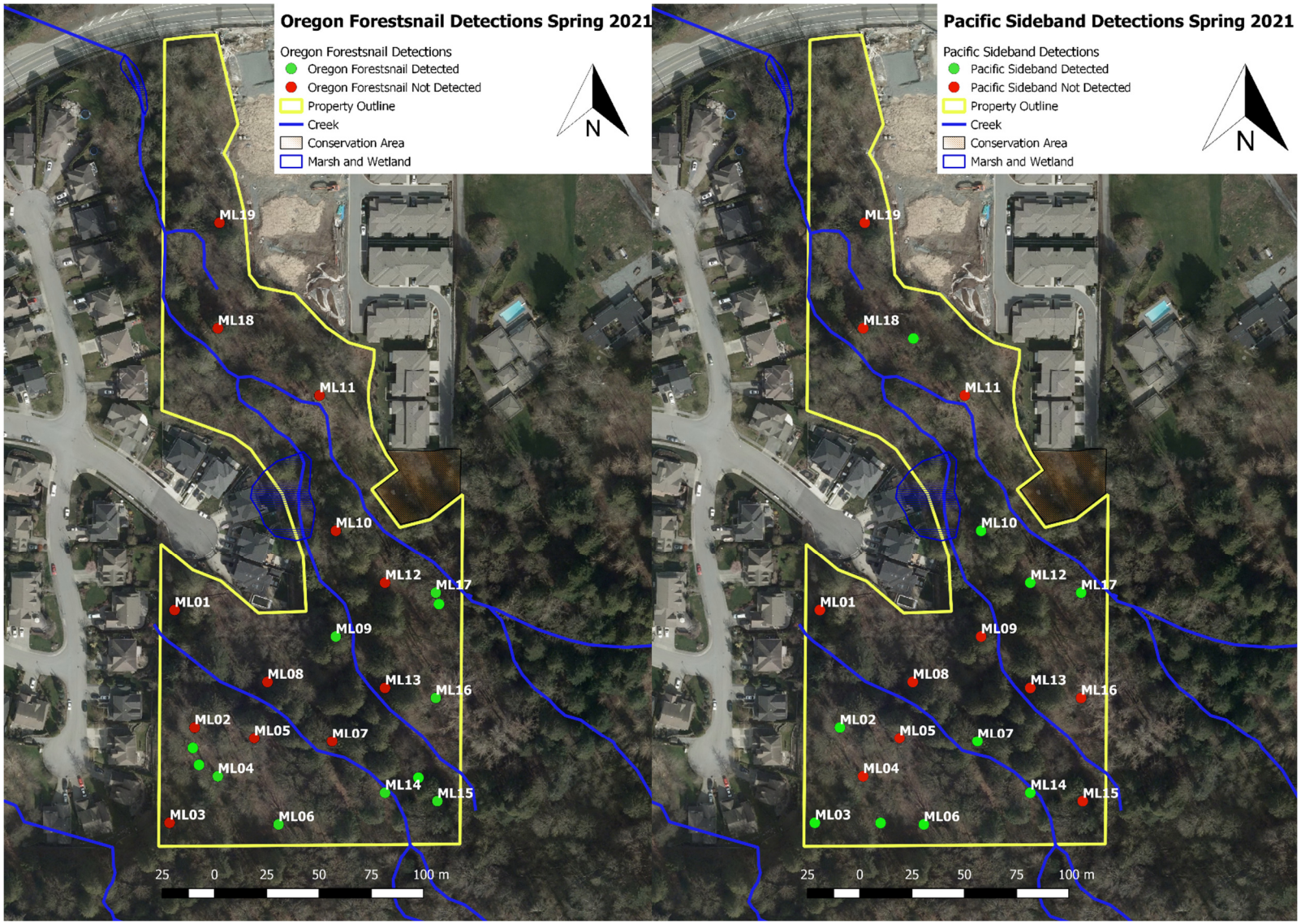

Figure 3: Maps showing locations of Oregon forestsnail (n=30) and Pacific sideband (n=16) detections from the 2021 spring surveys. Projection: UTM NAD 1983. Data compiled from the Fraser Valley Conservancy and the City of Abbotsford.

Fall Surveys 2021

The fall survey was conducted on October 6th, and in total, 76 gastropods were identified (31 live; 45 dead) during the survey. See Table 3 for a list of species and numbers identified. The average number of gastropods per plot was 4 (n=19). For both Oregon forestsnails and Pacific sidebands we detected 6 alive and 2 dead snails. Incidental sightings between plots totalled 9 Oregon forestsnails and 7 Pacific sidebands (Figure 4). Out of the 17 Oregon forestsnails found, 3 were previously marked, however one number was not legible, but the nail polish was grey which means it was marked between 2018-2020. One Pacific sideband out of 15 was recaptured but the number was also not legible.

Table 3: Gastropod species identified, numbers found dead and live, and the number of plots containing each species for fall surveys 2021.

Common Name	Scientific Name	# Live	# Dead	Total	% Plots	Avg/plot
Oregon forestsnail	*Allogona townsendiana*	2	6	8	21	0.4
Pacific sideband	*Monadenia fidelis*	2	6	8	26	0.4
Lancetooth	*Haplotrematidae family*	11	27	38	79	2.0
Chocolate arion	*Arion rufus*	0	0	0	0	0
Northwest hesperian	*Vespericola columbianus*	5	4	9	26	0.5
Grove snail	*Cepaea nemoralis*	0	2	2	10	0.1
Pacific banana slug	*Ariolimax columbianus*	11	0	11	37	0.6

The average size of live Oregon forestsnails found, including incidental observations (n=3), was 29.2 mm while the average size for live Pacific sidebands (n=4) was 33.6 mm. Table 4 details the minimum, maximum and average sizes of these species.

Table 4: Average measured size of Oregon forestsnail and Pacific sideband for live and dead specimens found for fall surveys in 2021. Not all dead specimens were measured due to shell damage.

	Average Size (mm)	SD	Minimum (mm)	Maximum (mm)
Live Oregon forestsnail (n=3)	29.2	0.5	28.7	29.8
Dead Oregon forestsnail (n=8)	28.4	24	23.9	31.1
Live Pacific sideband (n=4)	33.6	0.9	32.1	34.7
Dead Pacific sideband (n=11)	33.2	1.6	31	35.3

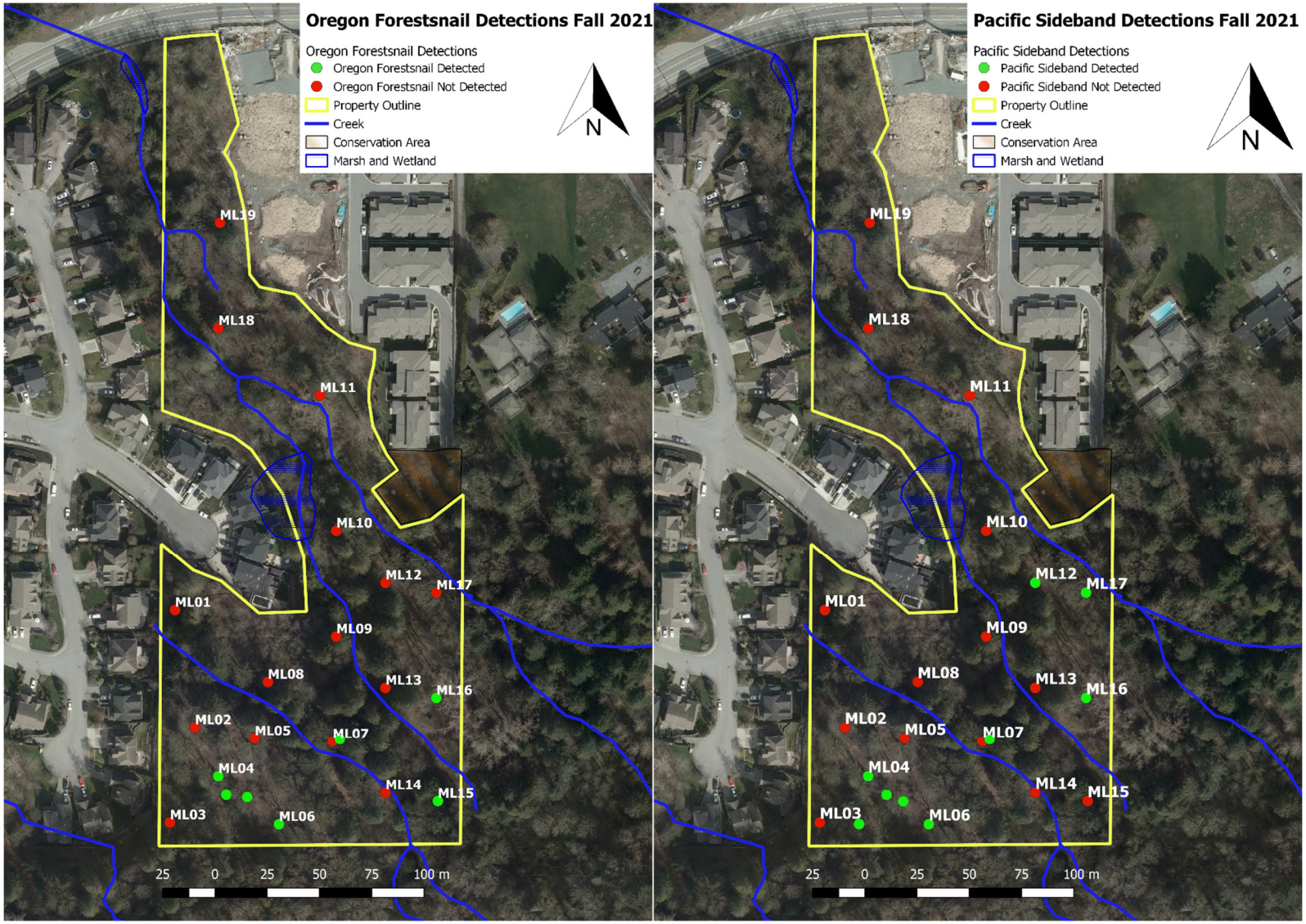

Figure 4: Maps showing locations of Oregon forestsnail (n=17) and Pacific sideband detections (n=15) from the 2021 fall surveys. Projection: UTM NAD 1983. Data compiled from the Fraser Valley Conservancy and the City of Abbotsford.

Summary 2014-2021 Oregon Forestsnails

The total number of Oregon forestsnails found in 2015-2017 was between 4 – 24 snails (Table 5). Interestingly, in 2014, 2018, 2020, and 2021 we detected between 47-60 Oregon forestsnails, almost a doubling compared to previous years. For all years, the detection of live snails is higher in the spring. The Oregon forestsnails are not found in uniform distribution across the site. The highest densities of snails have consistently been found in the southern section of the parcel (Figure 5).

Table 5: Summary total number of Oregon forestsnails found per year during the spring and fall surveys (in brackets is % live). In 2019 only one fall survey was conducted.

Year	Spring	Fall	Total	Plots	Incidental	Recapture Rate
2014	35 (29%)	25 (8%)	60	41	19	NA
2015	21 (%)	3 (0%)	24	10	14	4%
2016	10 (30%)	0	10	6	4	0
2017	3 (33%)	1 (0%)	4	4	0	0
2018	53 (66%)	3 (0%)	56	9	47	21%
2019	NA	1 (100%)	1	1	0	100%
2020	37 (89%)	10 (50%)	47	13	34	28%
2022	30 (67%)	17 (18%)	47	28	19	20%

Figure 5: Heatmap showing where the highest densities of Oregon forestsnails were found at Three Creeks in 2014-2021 (n=207). Projection: UTM NAD 1983. Data compiled from the Fraser Valley Conservancy and the City of Abbotsford.

Recapture Data Oregon Forestsnail and Pacific Sideband

To date, we have marked 280 snails (170 Oregon forestsnails, 110 Pacific sideband snails) of which 39 snails have been recaptured, including 2 snails that have been recaptured three times (Table 6). This year we recaptured 9 Oregon forestsnails and 1 Pacific sideband. Unfortunately, the numbers on 8 snails were not eligible or numbers were missing, so we were not able to exactly ID the snails. We had two snails (# 271 & # 276) that were recaptured both in the spring and fall in the exact same location. This is also the second and third time these two snails have been recaptured. Distance travelled between recaptures ranges from 0-76 m with the average being 22(SD±18) m. Recapture time ranges from 1 month to 5.4 years, with an average recapture time of 13.8 (SD±14.9) months (Figure 6).

Interesting to note that in 2018, 3 Oregon Forestsnails that were first marked on May 3rd in the same location were all found May 30th together 19 m southeast of the original location, all in aestivation. Similarly, 2 other Oregon forestsnails that were originally found together on May 3rd, 2018, were also recaptured together 14 m southeast of the original location, in aestivation. To date, the oldest recapture is an Oregon forestsnail that was originally captured and marked May 29th, 2015, and was then recaptured alive and in good condition 5.5 years later October 20th, 2020. Its shell had grown by 1 mm.

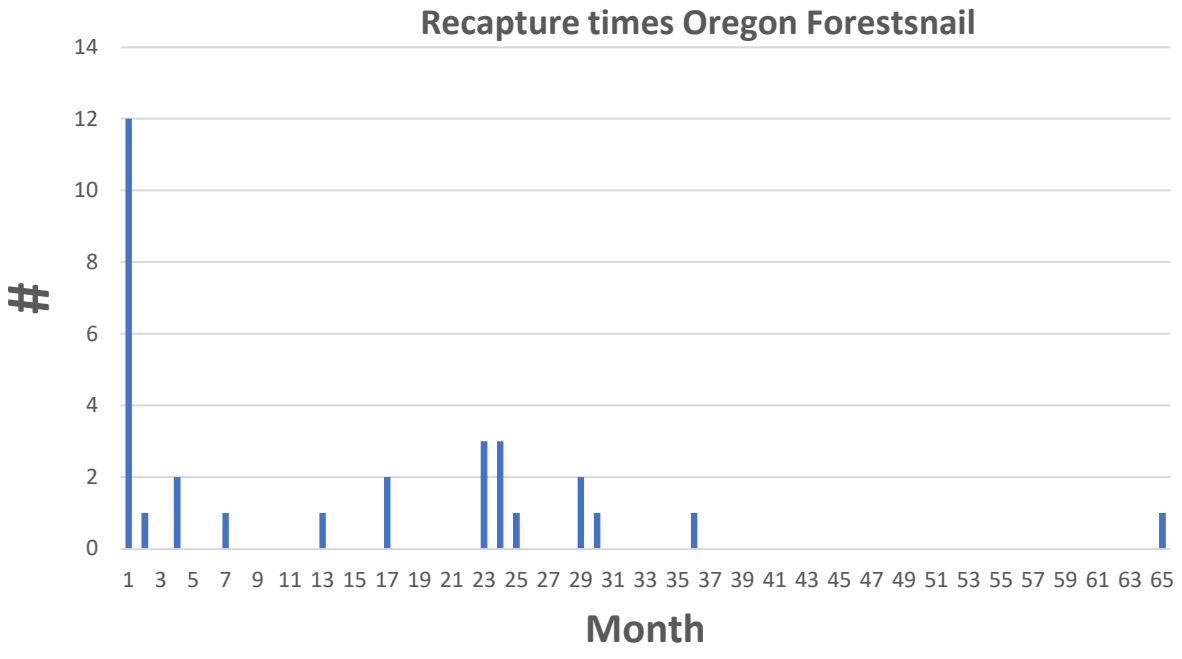

Figure 6: Recapture times in months for Oregon Forestsnails and Pacific Sidebands (n=32). The average recapture time was 14±15 months.

Table 6: Recapture data from our mark-recapture study 2014 – ongoing (n=280 marked Oregon forest and Pacific sideband snails), for snails with eligible numbers: 19 snails have been recaptured once, three snails have been captured twice, and two snails have been recaptured 3 times.

Date	#	Sp	Shell Diam mm	Condition	Microhabitat	Recapture Date	Distance Travelled m[1]	Microhabitat	Shell Diam mm	Condition	Comments	Recapture time months[2]
02-Apr-15	70	OFS	26.2	Live	In nettle	29-May-15	58	Under sword fern		Dead		1.9
29-May-15	68	OFS	26.4	Live	In nettle	30-May-18	5	Buttercup, fringecup, lady fern, maple, leaf litter, stinging nettle	29.6	Live		36.1
29-May-15	67	OFS	27.1	Live	In nettle	20-Oct-20	NA	Sword fern, Indian plum, salmonberry, stinging nettle	28.1	Live	In good condition	64.8
29-May-15	70	PSB	32.7	Live	NA	29-Oct-16	0	NA		Dead		17.1
03-May-16	89	OFS	23	Live	Pacific waterleaf	03-May-18	76	On leaf litter, nettle, salmon berry, Indian plum, ferns, shade	29.4	Live		24.0
03-May-16	95	OFS	24	Live	On leaf litter	03-May-18	NA	Same as above	26.4	Live		24.0
03-May-18	204	OFS	28.3	Live	On leaf litter, nettle, salmon berry, Indian plum, ferns, shade	30-May-18 20-Oct-20	18 35	NA Maple, stinging nettle, swordfern	NA 28.3	Live Dead	204, 207, and 210 in same location on both dates, Recap 1: Aestivation.	0.9 28.7
03-May-18	207	OFS	28.8	Live	Same as above	30-May-18 01-Jun-20	19 22	NA Nettle, snowberry	NA 27.4	Live	Recap: Uncertain as to why OFS is	0.9 24.1

											smaller, aestivation	
03-May-18	210	OFS	27.6	Live	Same as above	30-May-18	19	NA	NA	Live		0.9
03-May-18	211	OFS	27.8	Live	Same as above	20-Oct-20	19	Sword fern, Indian plum, salmonberry, stinging nettle	29.8	Dead		29.6
03-May-18	213	OFS	28.6	Live	NA	30-May-18	14	NA	NA	Live	Old number non-eligible, added new number. 213 and 215 in same location on both dates, Recap: Aestivation	0.9
03-May-18	214	OFS	28.2	Live	NA	30-May-18 23-Oct-19	11 22	On top of lady fern	NA	Live	2nd Recapture 23-Oct-19: underneath leaf litter close to fern and nettles, and in aestivation moved 22m.	0.9 16.8
03-May-18	215	OFS	26.6	Live	NA	30-May-18	14	Underneath leaf litter	NA	Live		0.9
03-May-18	217	OFS	28.5	Live	NA	30-May-18	24	NA	NA	Live		0.9
03-May-18	218	OFS	28.1	Live	NA	01-Jun-20	45	Big leaf maple, Pacific waterleaf, sword fern, vine maple, stinging nettle	28.2	Live		25

03-May-18	219	OFS	26.8	Live	NA	30-May-18	19	Buttercup, fringecup, lady fern, maple, leaf litter, stinging nettle	26.8	Live		0.9
03-May-18	238	PSB	34	Live	NA	30-May-18	6	NA	NA	Live	Recap: Aestivation, with leaf attached to membrane	0.9
05-May-20	250	OFS	30	Live	Stinging nettle, ferns, leaf litter	01-Jun-20	NA	NA	NA	Live	GPS coordinate for May was incorrect	0.9
05-May-20	252	OFS	28.1	Live	Stinging nettle, ferns, leaf litter	01-Jun-20	10	Stinging nettle, fern	NA	Live		0.9
30-May-18	270	OFS	28.2	Live	buttercup, fringecup, lady fern, maple, leaf litter, stinging nettle	05-May-20	4	NA	28.4	Live	Recap: Good condition, shell is bleached	23.2
30-May-18	271	OFS	28.4	Live		20-Oct-20 25-May-21 06-Oct-21	33 54 0	Maple, stinging nettle, sword fern	28.4 28.0 28.7	Live	Aestivation	28.7 7 4
30-May-18	274	OFS	29.2	Live		05-May-20	26	Stinging nettle, fern, leaf litter	29.2	Dead		23.2

30-May-18	276	OFS	29.1	Live	Stuck on fern	05-May-20 25-May-21 06-Oct-21	21 16 0	Stinging nettle, ferns leaf litter and moist ground	29.1 28.7 29.0	Live	Aestivation, Recap: In good condition, shell bleached	23.2 13 4
05-May-20	361	OFS	30.2	Live	On top of leaf litter, nettles, ferns, pacific waterleaf	01-Jun-20	31	Big leaf maple, Pacific waterleaf, sword fern, vine maple, stinging nettle	NA	Live	Missing parts of shell lip	0.9

[1]Second recapture distance is measured from first to second recapture site.

[2]Second recapture time is the differential in time between the first and second recapture date, and third recapture is the differential between the second and third recapture date and so on.

Discussion

The Three Creeks property supports a diverse group of native gastropods. However, we consistently find the highest densities of Oregon forestsnails and Pacific sidebands in the southern half of the property. In general, the southern portion is more continuous, has less impact from edge effects and fragmentation, and contains the habitat attributes typically associated with Oregon forestsnails, such as bigleaf maple, stinging nettle, Pacific bleeding heart and ferns (Heron 2018). Further, over the past 6 years, the northern portion of the property has been developed on all sides, except for a small buffer along the western edge. Consequently, some larger recently exposed trees on the property have come down, there has been an increase in sun exposure, soil compaction and possibly some hydrological changes.

Since 2018, we have doubled our survey efforts in the spring as this is the snails' breeding season and they actively cluster and seek mates. Our two 2021 spring surveys were conducted on May 7th and May 25th, and we found a total of 30 Oregon forestsnails and 16 Pacific sidebands. This year most of the Oregon forestsnails (n=20) were found in the plots and as in previous years, there was a hotspot in the southern portion of the property (Figure 5). Group clustering during the breeding season is a well documented phenomenon for the Oregon forestsnail (OFRT 2012).

This year we recaptured 9 Oregon forestsnails and 1 Pacific sideband. We are pleased with a 20% recapture rate, but unfortunately for 8 of the snails the identification number wasn't legible. As we noticed this in the field, we changed nail varnish and ensured numbers were clearly legible when marking new snails. This was the second and third recapture for two Oregon forestsnails, both of which were alive and in good condition and originally marked May 30th, 2018. As expected, there were fewer Oregon forestsnails and Pacific sidebands detected during the fall surveys, and most snails were found dead. In total, 2 live and 6 dead Oregon forestsnails and the exact same number of Pacific sidebands. There was low correlation in respect to detecting both Oregon forestsnails and Pacific sidebands in the same plots (r=0.20, n=19)

Since 2014 we have marked 170 Oregon forest and 110 Pacific sideband snails, as part of our ongoing mark-recapture study (n=280). To date, we have had 39 recaptures (31 Oregon forestsnails, 3 Pacific sidebands), of which three Oregon forestsnails have been recaptured twice and two Oregon forestsnails have been captured three times. The distance travelled has ranged from 0-76 m, with an average of 22(SD±18) m. The oldest live recapture is an Oregon forestsnail (#67) that was captured and marked May 29th, 2015 which was then recaptured alive and in good condition five years later October 20th, 2020. The recaptured snails are found in more open deciduous areas where bigleaf maples are dominant and there is an abundance of stinging nettle, Pacific waterleaf, leaf litter as well as moist porous (non-compact soil).

The snail surveys at three creeks have been ongoing since 2014, and it's interesting to note the clear delineation between the northern and the southern portion of the property in respect to snail detections. The northern portion has been void of Oregon forestsnails, except for 6 dead Oregon forestsnails detected during the first spring survey in 2014 (plot 19). Pacific sidebands are also rarely detected in this area, and this fall was the first time a live Pacific sideband was detected in the northern portion in plot 10. We attribute this to two main factors, lack of suitable habitat for the species in this area such as bigleaf maples and associated leaf litter on the ground, and nettles. The soil in certain areas is very compact and disturbed due to historic land use and ongoing invasive species removal. Urban development may also be a factor, residential development has occurred along all sides of the property, except the southern and southeastern property line. This has led to soil disturbance and compaction, tree clearing, increased littering, and human encroachment.

As in previous years, we detected some non-native grove snails. Three dead this year, 2 in plot 1 and one in plot 4, both plots are located along the western boundary where there is single home residential development and the gardens back on to Three Creeks. Since the beginning of this study the grove snails have consistently been located along this boundary. We are encouraged by the fact that the grove snails have not been detected at plots located at the center of Three Creeks and for now at least seem to be along the perimeter of the property bordering residential gardens.

Recommendations

The BMP for Oregon forestsnails recommends conducting surveys in April - June as this is when the snails are found to be most active (Heron 2018). Our survey results correspond well with this assertion, as to date, we have found substantially more Oregon forestsnails and Pacific sidebands during the spring survey versus the fall surveys. We recommend conducting two spring (April-May) surveys in order to maximize survey efforts during the breeding season.

For future snail monitoring studies, if you want detailed information on survival and abundance, we recommend setting up a study design that would allow for mark-recapture analysis using program MARK. For example, we will need a minimum of three site visits within a season to get survival estimates and have higher recapture rates than we had in the beginning of this study. Irrespective of this, we are pleased that we had the second highest recapture rate documented to date in 2021 (20%). Further, pit-tagging snails instead of numbering with nail varnish is more reliable. Unfortunately, we had 8 recaptures in 2021, where the numbers were not legible.

In conclusion, continued monitoring of these populations will provide a better understanding of the life cycle for both snail species. Learning more about the endangered Oregon forestsnail will also enable us to better protect this species in the future.

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Appendix A

Three Creeks Gastropod Survey Protocol

Purpose:
To increase our knowledge of the at-risk gastropod species occurring on this property and to monitor these snail populations.

Equipment List:

- Map
- Site data card
- Mark recapture data card
- clipboard
- Pencil
- Gate key
- Waterproof notebook
- Black nail polish
- Calipers
- Flags (6)
- GPS
- Camera
- Clinometer?

Field Procedures:

1. To access the site enter from locked Gate at the end of Logan Avenue.
2. Locate plots by referring to the map. Plots will be marked with a piece of rebar with flagging tape.
3. From the plot marker measure a 5 m radius and place flags around the perimeter.r
4. 20 person minutes (6 minutes and 20 seconds with three surveyors and 5 minutes with four surveyors) will be spent searching the plot for gastropods.
5. To search for gastropods, sift through leaf litter, under vegetation and on/under logs and tree trunks.
6. Place any specimens in a container for later identification to avoid interrupting the search time.
7. Once the search time is over identify, record, and mark any specimens.
    a. Distinguish between live and dead specimens.
    b. Measure Oregon Forestsnail and Pacific sideband using calipers.
    c. Give a unique number identifier (*how do you know what to start at)

   d. Mark using black nail polish.
   e. Return live snails where they were found and leave empty shells at plot center.

8. If incidental snails or shells are found mark and measure them and record a GPS location. Record I for incidental in the "plot #" column.

Filling out the Data Form:

1. A site card is filled in for each plot
2. The top portion of the card describes the site details
   a. Location will be Three Creeks
   b. Aspect is the direction the slope is facing
   c. Slope is the angle of the slope
   d. For overstory record dominant tree cover
   e. For moss cover record a general statement (e.g. low, medium, high)
   f. For CWD record number of pieces
3. The middle potion of the card describes the micro habitat
   a. Inundated means flooded
   b. Dry-mesic means there is a moderate or well-balanced amount of moisture
4. The bottom portion of the card describes the species found
5. A separate data card (the mark recapture card) is used to record snail measurements. Be sure to make note of any recaptures.
   a. Aestivation means a state of dormancy. You can identify a state of aestivation by….
6. *a list should be added here of drop-down options from filemaker once they are decided to make for consistent data*

Species of Interest at Three Creeks

Oregon Forestsnail

- Deep central whorl on the underside of shell
- Thickened shell lip

Pacific Sideband

- Deep central whorl on the underside of shell
- Usually seep pink, dark orange or burgundy
- Distinct band on side of shell

Northwest Hesperian

- Deep central whorl on the underside of shell
- tiny hairs all over shell

Lancetooth

- deep central whorl on the underside of shell

Grovesnail

- lacks deep pit on the underside of the shell
- shell patterns vary
- typical garden snail

Chocolate Arion

- hole on side of slug
- wrinkled surface

Banana Slug

- hole on the side of slug
- usually have a yellowish body but can be green, brown, or white
- large (up to 25 cm)

SITE DETAILS	Date		Surveyor(s)		Overstory	
	Plot #		Plot size		Moss Cover	
	UTM		Location		CWD	
	Start Time		Aspect		Soil comments	
	End Time		Slope			

MICROHABITAT	Light:	☐ Open	☐ Filtered	Moisture:	☐ Inundated ☐ Dry-mesic
		☐ Partial	☐ Shade		☐ Saturated (wet-mesic) ☐ Dry (xeric)
	Slope Position:	☐ Crest	☐ Lower Slope		☐ Moist (mesic)
		☐ Upper slope	☐ Toe of Slope	Disturbance:	☐ Erosion ☐ Natural
		☐ Mid slope	☐		☐ Soil compacted ☐ Grazed
	Other:	☐			☐ Contaminants present ☐ Disturbed

SPECIES	Species	# Alive	# Dead	Condition	Species	# Alive	# Dead	Condition
	Oregon Forestsnail				Grovesnail			
	Pacific sideband				Chocolate Arion			
	Northwest Hesperian				Banana slug			
	Lancetooth							

Location			Date		Surveyors		
Mark ID on shell	Plot #	Recapture? (y/n)	Shell Diameter* (mm)	Breeding (y/n) Eggs (y/n) With hatchlings (y/n)	Aestivation (y/n)	General health of individual	Microhabitat conditions